A field survey of the decapod crustaceans (Malacostraca: Decapoda) of the Pilliga Scrub in northern inland New South Wales

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Abstract
The Pilliga Scrub is a large semi-arid woodland area in northern inland New South Wales with limited freshwater habitats and a frequent scarcity of surface water. A survey of the area's decapod crustacean fauna in 2009-2010 identified five species: the crayfish *Cherax destructor* (Parastacidae), crab *Austrothelphusa transversa* (Parathelphusidae), shrimps *Caridina mccullochi* and *Paratya australiensis* (Atyidae) and prawn *Macrobrachium australiense* (Palaemonidae). The decapod diversity is low at the species level but relatively high at the family level, and reflects the location of the Pilliga Scrub in a transitional zone between faunal assemblages of southern and northern Australia. *Cherax destructor* and *Austrothelphusa transversa* are well suited to the variable aquatic conditions in the Pilliga Scrub and can survive prolonged drought in burrows. *Caridina mccullochi*, *Paratya australiensis* and *Macrobrachium australiense*, in contrast, are dependent on surface water at all life cycle stages, and their survival in the Pilliga Scrub relies on the few small permanent waterholes along larger intermittent streams or, if these dry out, re-colonisation from downstream perennial river channels during occasional stream flow events. An increase in aridity due to anthropogenic climate change could result in the local extinction of these three species, representing a 60% reduction in local decapod species diversity. (*The Victorian Naturalist* **128**(3) 2011, 96-105)

Keywords: decapod diversity, Pilliga Scrub, Murray-Darling Basin, intermittent streams

Introduction

Australia is one of the world's driest continents, with relatively limited freshwater habitats (Jones and Morgan 1994). Despite this, Australia has a diverse range of freshwater crustaceans, many with specialised life history traits enabling them to survive and even thrive under extremely variable conditions. The decapod crustacean fauna (Malacostraca: Decapoda) found in Australian freshwater habitats consists of crayfish (Parastacidae), shrimps (Palaemonidae and Atyidae) and crabs (Parathelphusidae and Hymenosomatidae) (Jones and Morgan 1994; Davie 2002a and b). The biogeographical origin of this fauna is varied, ranging from ancient Gondwanan relicts such as the parastacid crayfish (Merrick 1993) to relatively recent colonisers from south-east Asia, such as the Parathelphusid (potamid) freshwater crabs (Bishop 1963). Decapod crustaceans play a key ecological role in many freshwater ecosystems, often comprising a significant part of the macroinvertebrate biomass, feeding at multiple trophic levels and forming an important food source for fishes and waterbirds (Sheldon and Walker 1998; Richardson and Cook 2006; Giling *et al.* 2009). Larger species are also of cultural significance to Australian Aboriginal people as a traditional bush food. Freshwater decapod faunas are of conservation concern in many parts of the world (Martin and Wicksten 2004; O'Brien 2007; Crandall and Buhay 2008; Cumberlidge *et al.* 2009). The present study examined the decapod crustacean fauna of the Pilliga Scrub in northern inland New South Wales (NSW). This is the first published study of the decapods of this area. The aim of the study was to identify the species present and document information on local distribution, habitat preferences and status.

Study area and methods

The Pilliga Scrub is a 450000 ha area of semi-arid woodland in *Gamilaraay* Aboriginal Country in the Brigalow Belt South bioregion in northern inland NSW (Fig. 1). The landform ranges from low sandstone hills and wide sandy valleys in the east to a flat outwash sand plain in the west and north, and has an elevation range of 160-640 m above sea level (Australian Height Datum). The Pilliga Scrub is within the Murray-Darling Basin: most of the area drains north to the Namoi River while the southern and south-western fringes drain south or west to the Castlereagh River. Rainfall is generally low and irregular

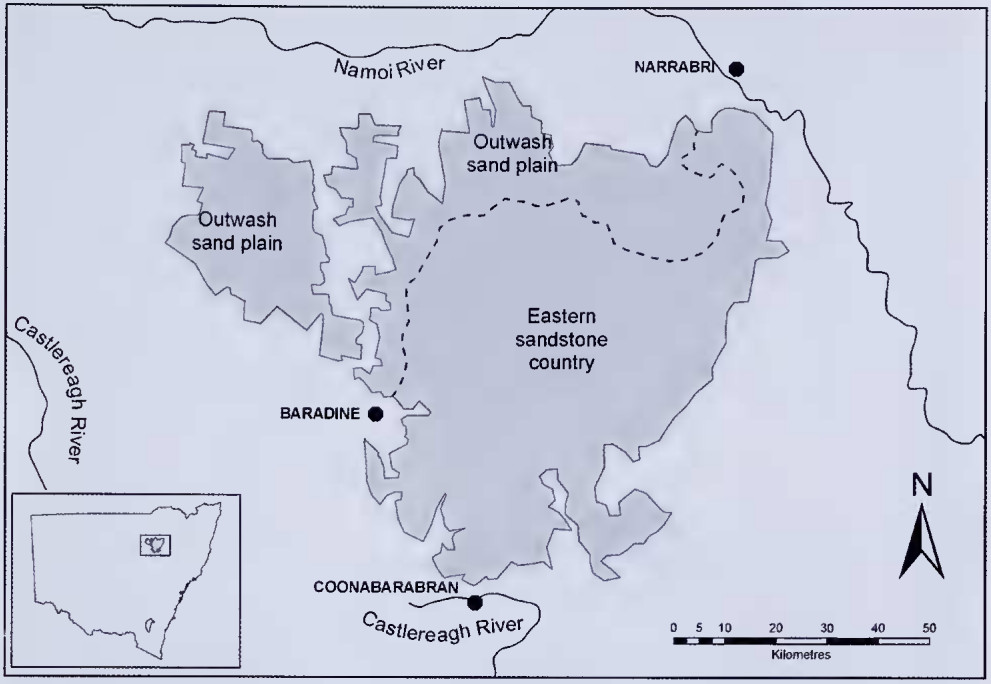

Fig. 1. Map of the Pilliga Scrub study area. The shaded area represents the approximate extent of the Pilliga Scrub. The dotted line marks the boundary between the eastern sandstone country and the outwash sand plain.

and the intermittent streams in the Pilliga Scrub represent an extremely variable and unpredictable aquatic environment, fluctuating between a few small isolated waterholes along dry stream beds for most of the year and temporarily flowing streams and shallow ephemeral wetlands following rare heavy rain events. Small earth-wall ground tanks used as a fire fighting resource provide some additional aquatic habitat.

A field survey of the decapod crustacean fauna of the Pilliga Scrub was done between September 2009 and June 2010. Considerable rainfall over the summer and autumn of 2010 resulted in strong stream flow events during part of the study period. Survey methods comprised funnel-type yabby traps baited with tinned cat food or chicken, dip-netting using a hand-held net, lifting timber debris and loose rocks around water edges, spotlighting at night along water edges and searching water edges and dry water bodies for exoskeleton material. Twenty primary survey sites were identified to systematically investigate broad patterns of habitat usage within the study area, and were stratified between the eastern sandstone country and the outwash sand plain and between natural streams/waterbodies and constructed ground tanks (Appendix 1). Opportunistic records from additional sites were also documented; generally based on observations of exoskeleton material but also including some opportunistic trapping and dip-netting. Taxonomic nomenclature in this paper follows Davie (2002a, 2002b). Voucher specimens of all species recorded in the study were deposited in the collection of the Australian Museum (Sydney).

Results

In total, 58 records of decapod crustacea were documented in the Pilliga Scrub study area, comprising five species from four families (Table 1). Overall site richness, based on the 20 primary survey sites, averaged 1.3 species per site (range 0–3 species). Site richness and species occurrence varied between the eastern sandstone country and the outwash sand plain and between natural streams/waterbodies and ground tanks (Table 1). Natural streams and

Table 1. Decapod site richness and species occurrence in the Pilliga Scrub. [1]Based on primary survey sites. [2]Based on primary and opportunistic records. [3]Opportunistic record.

	Proportion of sites where species was recorded [1]					Average species richness per site [1]	Overall species diversity [2]	Species present [2]
	Cherax destructor	*Austrothelphusa transversa*	*Paratya australiensis*	*Caridina mccullochi*	*Macrobrachium australiense*			
Natural streams/waterbodies - outwash sand plain	80%	20%	20%	0%	20%	1.4	5	*C. destructor* *A. transversa* *P. australiensis* *C. mccullochi* [3] *M. australiense*
Ground tanks – outwash sand plain	80%	0%	20%	0%	0%	1.0	2	*C. destructor* *P. australiensis*
Natural streams/waterbodies – sandstone country	100%	0%	60%	0%	20%	1.8	3	*C. destructor* *P. australiensis* *M. australiense*
Ground tanks – sandstone country	100%	0%	0%	0%	0%	1.0	1	*C. destructor*

waterbodies in the eastern sandstone country had the highest average species richness per site while natural streams and waterbodies on the outwash sand plain had the highest overall species diversity. Ground tanks in the eastern sandstone country had the lowest diversity.

The Common Yabby *Cherax destructor* Clark, 1936 (Parastacidae) (Fig. 2) was found to be common and widespread across the Pilliga Scrub (Fig. 3), recorded at 90% of the primary survey sites and found in a wide range of habitats including flowing streams, billabongs, natural waterholes, gilgai wetlands and ground tanks. Live animals were captured in water by trap and dip-net or were found in burrows beneath timber debris and loose rocks in drying waterbodies. Capture rates at several sites exceeded 10 animals per trap-night. Many of the opportunistic decapod records in this study were of exoskeleton remains of this species

Fig. 2. Common Yabby *Cherax destructor* from Baradine Creek, Pilliga Scrub. Photo by MJ Murphy.

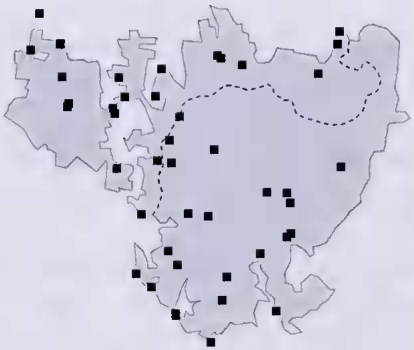

Fig. 3. Records of *Cherax destructor* in the Pilliga Scrub study area.

Fig. 4. Freshwater Crab *Austrothelphusa transversa* from Box Creek on the western margin of the Pilliga Scrub. Australian Museum specimen P.83245. Photo by MJ Murphy.

Fig. 5. Records of *Austrothelphusa transversa* in the Pilliga Scrub study area.

(usually the robust chelae) found on the water's edge or on the floor of dry waterbodies.

The Freshwater Crab *Austrothelphusa transversa* (Martens, 1868) (Parathelphusidae) (Fig. 4) was recorded at only one site (5% of primary survey sites), a tree-lined minor stream in the far west of the outwash sand plain (Fig. 5). This site, where exoskeleton remains of the species had been found on the dry stream bed during drought in August 2007, was revisited in January 2010 when the stream was flowing after extensive local rain over the previous month. Adult crabs were active at night in shallow water along the edge of the stream, retreating to burrows amongst inundated tree roots when disturbed. About 12 were seen in 15 minutes along a 50 m creek transect. Crabs were also trapped overnight.

The Glass Shrimp *Paratya australiensis* Kemp, 1917 (Atyidae) (Fig. 6) was recorded at 25% of the primary survey sites and opportunistically at several other sites (Fig. 7). Although records in the study area were widely distributed, most were from larger or more permanent waterholes along major streams, up to 150 km upstream of the Namoi River, with one additional record from a ground tank in the northern outwash sand plain. Shrimp were caught by dip-

Fig. 6. Glass Shrimp *Paratya australiensis* from Baradine Creek, Pilliga Scrub. Australian Museum specimen P.82090. Photo by MJ Murphy.

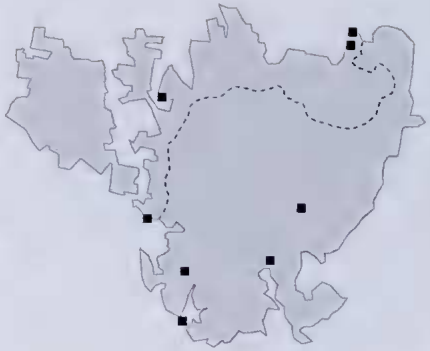

Fig. 7. Records of *Paratya australiensis* in the Pilliga Scrub study area.

net by day and were often taken near rushes and reeds.

McCulloch's Shrimp *Caridina mccullochi* Roux, 1926 (Atyidae) (Fig. 8) was not recorded at any of the primary survey sites but was recorded opportunistically at one site, a large, shallow reed-edged remnant waterhole on a dry major stream in the north-east of the outwash sand plain, only 24 km upstream of the Namoi River (Fig. 9). At this site *Caridina mccullochi* was sympatric with *Paratya australiensis* and *Cherax destructor*. Shrimp were caught by dip-net by day in March 2010.

The Common Australian River Prawn *Macrobrachium australiense* Holthuis, 1950 (Palaemonidae) (Fig. 10) was recorded at three sites (10% of primary survey sites and one opportunistic site) (Fig. 11). All sites were on major streams, up to 120 km upstream of the Namoi River. One site was in the eastern sandstone country and two on the outwash sand plain. The eastern site was a natural rocky waterhole which is permanent in all but extreme drought. The outwash sites were tree-lined pools in a shallow flowing stream following a strong stream flow event. Immature animals were trapped overnight at these sites in February–May 2010. The large adult animal pictured (Fig. 10) was found at the eastern site during drought in September 2007, sheltering by day under a rock when the waterhole was reduced to a small muddy puddle.

Fig. 8. McCulloch's Shrimp *Caridina mccullochi* (preserved specimen) from Bohena Creek, Pilliga Scrub. Australian Museum specimen P.83249. Photo by Roger Springthorpe © Australian Museum.

Discussion

The low species diversity of decapod crustaceans found in the Pilliga Scrub is not surprising, given the limited extent and variety of freshwater habitats present. The geographical position of the Pilliga Scrub is also outside Australia's major centres of freshwater decapod species diversity in the south-east highlands (Par-

Fig. 9. Records of *Caridina mccullochi* in the Pilliga Scrub study area.

Fig. 10. Common Australian River Prawn *Macrobrachium australiense* from Borah Creek, Pilliga Scrub. Photo by MJ Murphy.

Fig. 11. Records of *Macrobrachium australiense* in the Pilliga Scrub study area.

astacidae) (Merrick 1993; Crandall and Buhay 2008), Cape York Peninsula (Parathelphusidae) (Bishop 1963) and northern Australia (Atyidae and Palaemonidae) (Riek 1953; Short 2004).

The Pilliga Scrub's decapod diversity at the family level, however, is relatively high. Four of the five freshwater decapod families known from Australia (Jones and Morgan 1994; Davie 2002a, 2002b) are represented in the Pilliga Scrub fauna. The only family not present is the Hymenosomatidae (false spider-crabs), of which the single Australian freshwater species occurs in the lower Murray-Darling Basin and coastal rivers of South Australia, Victoria and Tasmania (Lucas 1980; Davie 2002b). On a global scale the four decapod families in the Pilliga Scrub can be compared to two families (23 species) in the Apalachicola River system of the southern USA (Hobbs and Hart 1959), three families (20 species) in the Nile Basin of Africa (Cumberlidge 2009), three families (19 species) in Vanuatu in the western Pacific (Marquet *et al.* 2002), six families (25 species) in Pulau Tioman in Peninsular Malaysia (Yeo *et al.* 1999) and six families (64 species) in the Guayana Shield region of northern South America (Magalhaes and Pereira 2007). A factor contributing to the diversity of freshwater decapod families represented in the Pilliga

Scrub is its geographical position in an overlap zone between faunal assemblages of southern and northern Australia.

Cherax destructor is the most widely distributed freshwater crayfish species in Australia, occurring naturally in inland waters of south-eastern and central Australia (Merrick 1993; Hughes and Hillyer 2003) and playing a key role in the ecology of aquatic ecosystems (Giling *et al.* 2009). It is a hardy species, well suited to the variable aquatic conditions in the Pilliga Scrub, being tolerant of poor water quality and able to survive droughts by retreating to water-filled chambers at the end of burrows below dry stream beds (Healy and Yaldwyn 1971; Jones and Morgan 1994). This was the only decapod species regularly found in ground tanks in the Pilliga Scrub study area. It is possible that populations in some ground tanks are the result of local translocation of animals for the purpose of founding recreational fishing stock.

Austrothelphusa transversa is found in streams, swamps, waterholes and ground tanks in northern and north-eastern Australia, and the Pilliga Scrub is at the south-eastern edge of the species' distribution (Bishop 1963; Healy and Yaldwyn 1971). This species is well adapted to arid and semi-arid areas. It does not have a planktonic larval stage (the eggs hatching as small crabs), it can breathe effectively in both air and water and can survive several years of drought by sheltering in burrows up to 1 m deep with the entrance closed with a clay plug (Bishop 1963; Greenaway *et al.* 1983; Davie 2002b). *A. transversa* is very difficult to detect in areas that have been dry for any length of time (Bishop 1963), and in the Pilliga Scrub roads are often impassable after wet weather, when the species is likely to be active. Although recorded in this study at only a single site, this cryptic species is probably sparsely distributed through the western part of the Pilliga outwash sand plain.

Paratya australiensis occurs in south-eastern Australia and coastal Queensland in habitats ranging from inland rivers to upland rainforest streams and estuaries (Walsh and Mitchell 1995; Hancock and Bunn 1997). It is most commonly found in rivers, streams and billabongs and can also occur in lakes, reservoirs, farm dams and ditches (Williams 1977; Sheldon and Walker 1998). In rivers and streams *P. australiensis* favours backwater areas sheltered from the direct stream flow (Humphries *et al.* 2006; Richardson and Cook 2006). Unlike the preceding two species, *Paratya australiensis* lacks a life cycle stage able to survive the drying of waterbodies (Williams 1977). Its occurrence in the Pilliga Scrub must therefore depend on either survival of remnant populations in the few small permanent waterholes along major intermittent streams or, if even these dry out, re-colonisation upstream from the Namoi or Castlereagh rivers during extended stream flow events.

Caridina mccullochi occurs in the Murray-Darling Basin and south-east coastal area of southern Australia where it is a local but sometimes common inhabitant of quiet weedy waters in lowland streams and rivers (Benzie 1982; Davie 2002a). Although superficially very similar to, and often found with, *Paratya australiensis*, *Caridina mccullochi* is more strongly associated with sheltered backwaters and is apparently more vulnerable to the effects of river regulation (Richardson *et al.* 2004; Humphries *et al.* 2006; Richardson and Cook 2006). Like *P. australiensis*, *C. mccullochi* lacks a life cycle stage able to survive drying. The present study suggests that *Caridina mccullochi* has been considerably less successful than *P. australiensis* in taking advantage of temporary stream flows to colonise the Pilliga Scrub.

Macrobrachium australiense is found in rivers, streams, billabongs, lakes and reservoirs in inland and coastal areas of eastern and northern Australia and is the only member of its family found in the Murray-Darling Basin (Murphy *et al.* 2004; Short 2004; Richardson and Cook 2006). In rivers and streams *M. australiense* larvae favour sheltered backwater areas while adults prefer flowing channel habitats (Richardson and Cook 2006). Large-scale upstream migration by this species has been observed following rain (Lee and Fielder 1979). This is another species vulnerable to desiccation at all life cycle stages and therefore dependent on surface waters for survival. An increase in aridity due to anthropogenic climate change could see the disappearance from the Pilliga Scrub of the few small permanent waterholes providing critical surface water refugia for *P. australien-*

sis, *C. mccullochi* and *M. australiense* during dry periods, as well as a reduction in frequency and duration of the stream flow events required for recolonisation. The local extinction of these three species would represent a 60% reduction in local decapod species diversity.

Genetics research has indicated that both *Paratya australiensis* and *Caridina mccullochi* may be species complexes comprising multiple lineages and previously unrecognised cryptic species (Baker *et al.* 2004; Page *et al.* 2005; Cook *et al.* 2006; Cook *et al.* 2008). Taxonomy is always a 'work in progress' and it is important to lodge voucher specimens from field surveys in Museum collections so that identifications can be substantiated and to provide reference material in the event of future taxonomic revisions. Voucher specimens from the present study (Appendix 2) comprised material from all sites where *Austrothelphusa transversa*, *Paratya australiensis*, *Caridina mccullochi* and *Macrobrachium australiense* were found and a representative sample of *Cherax destructor*.

Additional decapod crustacean species known from the Murray-Darling Basin in NSW but not recorded in this study include the Swamp Yabby *Cherax rotundus*, Burrowing Crayfish *Engaeus cymus*, Murray Crayfish *Euastacus armatus* and Sutton's Crayfish *Euastacus suttoni* (Parastacidae) (Merrick 1993; Austin *et al.* 2003; McCormack 2008). *Cherax rotundus*, *Engaeus cymus* and *Euastacus armatus* are found only in the southern part of the Murray-Darling Basin, while *Euastacus suttoni* is restricted to highland rivers of the New England Tableland and southern Queensland (Merrick 1993; Austin *et al.* 2003; McCormack 2008). None are expected to occur in the Pilliga Scrub.

The aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River (including lowland reaches of the Namoi and Castlereagh Rivers and all tributary streams and floodplains) is currently listed as an endangered ecological community (EEC) under the NSW *Fisheries Management Act* 1994 (NSW Fisheries Scientific Committee 2003). The listing includes all native aquatic invertebrates and fishes and covers all but the southern fringe of the Pilliga Scrub study area (which is within the upland catchment of the Castlereagh River). Threatening processes affecting this EEC include river regulation, water extraction, clearing of riparian vegetation, stock access to riparian areas, removal of in-stream timber debris, introduced species, insecticide and fertiliser run-off from agriculture, and overfishing (Koehn 1993; NSW Fisheries Scientific Committee 2003; Reid *et al.* 2008). As noted above, anthropogenic climate change should also be considered a threat.

The majority of the lowland catchment of the Murray-Darling Basin has been cleared for agriculture. In the Brigalow Belt South bioregion, for example, 64% of the bioregion's original native vegetation had been cleared by the late 20th century (State of the Environment Advisory Council 1996). The Pilliga Scrub is the largest surviving woodland area within the lowland catchment of the Darling River system in NSW and, despite the frequent scarcity of surface water and limited freshwater habitats, supports a rich aquatic macro-invertebrate community. In addition to the five decapod crustaceans documented here, other crustaceans recorded in the Pilliga Scrub during this study include fairy shrimps (Anostraca), shield shrimps (Notostraca) and clam shrimps (Conchostraca) (Murphy pers. obs.). A high diversity of aquatic molluscs is also present, including species rare in NSW such as the mussel *Velesunio wilsonii* (Hyriidae) and the freshwater snails *Notopala* sp. (Viviparidae) and *Bayardella cosmeta* (Planorbidae) (Murphy 2009). The high proportion of native woodland vegetation comprising stream catchments in the Pilliga Scrub is probably a major factor in the survival there of a relatively intact and significant example of the lowland Darling aquatic EEC macro-invertebrate fauna.

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Appendix 1. Location of primary survey sites.

Natural streams/waterbodies - outwash sand plain	
Baradine Creek, Baradine-Pilliga Road at Gwabegar bridge	30°37'51.0"S, 148°58'8.3"E
Old Coghill Waterhole, Pilliga National Park	30°29'29.5"S, 149°18'17.4"E
Creek north of Hollywood Boundary Road	30°33'30.5"S, 148°35'15.4"E
Yellow Creek, Pilliga-Coonamble Road	30°27'27.5"S, 148°48'5.6"E
Bohena Creek, Cains Crossing	30°24'45.1"S, 149°40'26.2"E
Ground tanks – outwash sand plain	
Bens dam, Pilliga State Conservation Area	30°35'53.4"S, 149°6'2.9"E
Trap Yard dam, Merriwindi State Conservation Area	30°47'38.5"S, 148°58'59.3"E
Camp Reserve dam, Pilliga National Park	30°32'53.6"S, 148°59'7.1"E
Middle dam, Pilliga West State Conservation Area	30°37'45.1"S, 148°49'30.9"E
Dead Filly tank, Pilliga West State Conservation Area	30°34'48.1"S, 148°46'44.1"E
Natural streams/waterbodies – sandstone country	
Yearinan Creek bridge, Coonabarabran-Baradine Road	31°10'58.8"S, 149°10'33.2"E
Timmallallie Creek bridge, Newell Highway	30°51'4.8"S, 149°27'26.3"E
Swindle Well Crossing, Timmallallie National Park	31°3'6.8"S, 149°10'48.2"E
Salisbury Waterholes, Pilliga Nature Reserve	30°52'44.3"S, 149°31'49.9"E
Dandry Creek, Narawa Road	31°8'46.4"S, 149°19'20.3"E
Ground tanks – sandstone country	
Timmallallie dam, Timmallallie National Park	30°55'8.0"S, 149°16'26.7"E
Bark Hut dam, Timmallallie National Park	30°54'45.9"S, 149°12'33.8"E
Delwood dam, Pilliga East State Conservation Area	30°46'46.4"S, 149°41'17.6"E
Lizard dam, Yarrigan National Park	31°4'40.0"S, 149°2'56.3"E
Cocaboy dam, Pilliga East State Conservation Area	30°51'10.1"S, 149°31'12.2"E

Appendix 2. Voucher specimens collected during this study and deposited in the Australian Museum, Sydney.

Cherax destructor	P.82091, P.82092, P.82095, P.83246
Austrothelphusa transversa	P.83245
Caridina mccullochi	P.83249
Paratya australiensis	P.82089, P.82090, P.82093, P.82094, P.83242, P.83248, P.83250, P.84121, P.84122
Macrobrachium australiense	P.83247, P.83251, P.84120